A Field Based Depth Correction Algorithm for Submerged Aquatic Vegetation Spectra

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Abstract

Anthropogenic sources of nutrients in aquatic systems are known to degrade ecosystem health. Aquatic managers are reliant on intensive and destructive methods to understand the abundance of primary producers, which is one component of assessing ecosystem health. Remote sensing has the potential to provide non-destructive and efficient sampling of aquatic biomass, however, the effects of the water column on spectral signatures must be corrected. This study seeks to apply a water column depth correction for spectra in a field setting. A white panel and a black panel were submerged at incremental depths, with the spectra signature recorded using a spectroradiometer at each increment. Using model inversion the spectral signatures of the panels were used to correct the spectra of submerged aquatic vegetation, significantly clarifying the spectral signature. More work is required to assess the ability of the algorithm to improve the results of biomass estimation and classification.

Background and Relevance

Nutrient inputs in aquatic systems such as rivers, lakes and streams are known to increase primary productivity of submerged aquatic vegetation and biomass in-turn (Askey et al 2007). As the increased biomass respires, anoxic or more commonly hypoxic conditions can result in fish kills and unhealthy ecosystems. To understand, model and predict the health of aquatic ecosystems, managers are reliant on few discrete point samples of submerged aquatic vegetation using intensive and destructive sampling methods. The Bow River in Alberta, Canada has few nutrient inputs above the City of Calgary. However, wastewater treatment plants in the city release substantial volumes of nutrient rich effluent that alters aquatic ecosystems downstream (Askey et al 2007).

Remote sensing has proven effective for the delineation of submerged aquatic vegetation and to a lesser extent, the classification and estimation of biomass (Yuan and Zhang 2007, Cho et al 2008, Armstrong 1993, Dillabaugh and King 2008, Diersen et al 2008). Compared to terrestrial applications, the effectiveness of remote sensing of submerged aquatic vegetation has been limited owing to the degradation of spectral signal by the water column (Cho et al 2008). Depth-correction algorithms have been developed and applied to ocean and coral based studies since the 1980's, most notably the Lyzenga method and modifications there of (Yang et al 2010, Tassan 1996). These corrections are well established and effective. However, water depths beyond light penetration are required for their creation, a characteristic which is not found in shallow inland water bodies including rivers, lakes and streams. Recently, shallow water corrections have been presented and proven effective in controlled experiments (Cho and Lu 2010, Yang et al 2010). However, these techniques have not been tested in applied field settings. This study seeks to apply a modified version and Cho and Lu's (2010) depth correction in a field application of biomass estimation and vegetation classification using a spectroradiometer.

Methods and Data

Data collection occurred during the fall of 2010 at three study plots in a reach of the Bow River in Calgary, Alberta. The study plots were located downstream of the Bonny Brook waste water treatment plant, the most substantial point source of nutrients to the Bow River within Calgary.

Following an adaptation of Cho and Lu's (2010) methods for water correction, at each plot a white panel and a black panel were submerged incrementally from the water surface to the maximum depth which could be safely sampled (governed by water depth and flow). At each 6.5 cm increment, a spectroradiometer was used to record the spectral signal of the white panel and the black panel respectively through a range of wavelengths from 330 nm - 1100 nm in 1 nm increments. Following a systematic sampling design, the spectral signatures of submerged aquatic vegetation were recorded. The vegetation which corresponded to the instantaneous field of view of the instrument was then harvested, identified, dried, and weighted to obtain dry weight, an estimate of biomass. The absorbance (white panel) and reflectance (black panel) values of the water column were modeled by fitting a least-squares function to the measurements, in the form of spectra as a function of depth. This was repeated for every wavelength recorded, storing the slope and intercept of the functions. The spectral samples of vegetation were then corrected for the effects of the water column by model inversion using the slope and intercept parameters.

Results

The depth correction algorithm has shown to significantly clarify the signal of submerged aquatic vegetation. Identification of the plant species and refinement of the algorithm are ongoing, therefore the effectiveness of the algorithm for biomass estimation and species classification is still forthcoming. However, owing to the significant improvement in signal following the correction, a significant improvement is anticipated. The complete results, including the effectiveness of the algorithm for biomass estimation and submerged vegetation classification will be completed shortly.

Conclusions

The current work seeks to share the progress to date on the development and application of a shallow-water depth correction algorithm in a field setting. This study is valuable as inefficient and destructive sampling methods are the only means currently used to assess the biomass and extent of submerged aquatic vegetation. Remote sensing has the potential to provide an efficient, non-destructive sampling method, however, corrections for the effects of the water column must be developed. The algorithm presented here, and applied in a field setting has shown a significant improvement in the spectral signal of submerged aquatic biomass.

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